RESEARCH DEPARTMENT

The portrayal of vertical detail by the Secam colour television system

RESEARCH REPORT No. T-153

1965/42

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

THE PORTRAYAL OF VERTICAL DETAIL BY THE SECAM COLOUR TELEVISION SYSTEM

Research Report No. T-153

(1965/42)

D. Maurice

G.D. Monteath, B.Sc., F.Inst.P., M.I.E.E.

for Head of Research Department

This Report is the property of the British Broadcasting Corporation and may not be reproduced in any form without the written permission of the Corporation.

Research Report T-153

THE PORTRAYAL OF VERTICAL DETAIL BY THE SECAM COLOUR TELEVISION SYSTEM

Section	Title	Page
	SUMMARY	1
1.	INTRODUCTION	1
2.	LIVE TRANSMISSION	3
3.	USE OF MODIFIED CODER FOR LIVE TRANSMISSION	4
4.	FILM TELERECORDING AND TELECINE WITH EXISTING CODERS	5
	4.1. Suppressed-field Telerecording	5
	4.2. Full-information Telerecording	9
5.	A SIMPLER METHOD OF REPRESENTATION	9
6.	DISCUSSION	14
7.	CONCLUSIONS	17
8.	REFERENCES	18

November 1965 Research Report No. T-153

(1965/42)

THE PORTRAYAL OF VERTICAL DETAIL BY THE SECAM COLOUR TELEVISION SYSTEM

SUMMARY

The SECAM system impairs the portrayal of vertical detail in three ways: it produces flickering moiré effects at horizontal boundaries between different colours, distributes chrominance information from one scanning line between two or more lines, thus blurring it vertically, and causes vertical misregistration between chrominance and luminance. These effects are considered theoretically for live transmission, stored-field telerecording and live telerecording. The use of modified coders, each incorporating three line-period delays, avoids the flickering moiré effects and the misregistration at the cost of an increase in the vertical blurring. If modified coders are not used, it is proposed to use a one-line luminance delay in the decoder preceding a telerecorder in order to avoid the misregistration.

1. INTRODUCTION

In the SECAM system, each colour-difference signal is transmitted only during alternate scanning lines and the missing colour-difference signal is made good in the decoder by the use of a line-period delay, as shown in Fig. 1. The discarding of

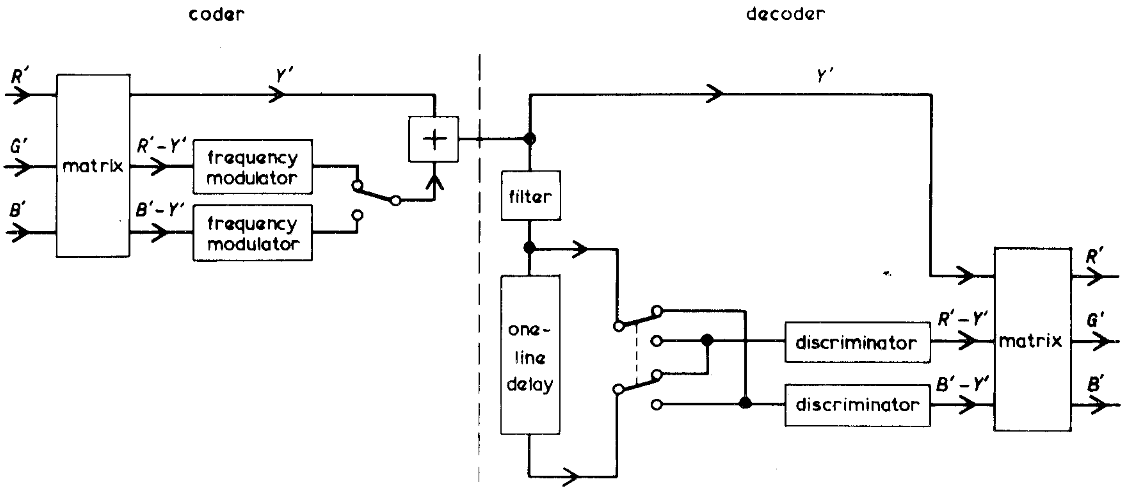


Fig. 1 - Existing SECAM coder and decoder

information in the coder is tantamount to an additional sampling process, which is superimposed upon the sampling inherent in scanning.

Scanning in a picture source, which has been discussed in an earlier report[1] has the effect of adding to the vertical spectrum* a displaced version of itself; these spurious components give rise to moiré patterns and other objectionable effects. The sampling inherent in a 625-line SECAM system resembles that in a monochrome system with only 625/4 = 156·25 lines per field; that is a system with a 4/1 interlace. The spurious components associated with such a system flicker at 12½ c/s.

The fact that a colour-difference signal generated during one scanning line is used in two successive scanning lines has a blurring effect tantamount to the discarding of some wanted components in the vertical spectrum. Moreover, the fact that half the colour-difference information is delayed by one scanning line causes vertical misregistration between luminance and chrominance. It is important to realize that we are here concerned with scanning lines that are adjacent in a single field, not in a complete picture.

The impairment of the picture by the effects discussed above is mitigated by a partial realization of the constant-luminance principle, since only colour-difference signals are involved. Nevertheless, it is sometimes noticeable, particularly when saturated colours are present. A flickering blur has sometimes been observed on lips covered with saturated lipstick.

In spite of the growing use of magnetic recordings, it is certain that there will be a requirement for telerecordings in colour since this is the only economical means of supplying many copies of a programme for export. Moreover, telerecordings have the further advantage of obviating the need for standards conversion. Unfortunately operational and other practical considerations make it virtually certain that the signal provided for telerecording will be coded, so that when a programme is transmitted by scanning a telerecording, it will have been subjected to the SECAM coding and decoding processes twice, and the impairment of the portrayal of vertical detail will be accentuated. It is true that film is not capable of combining high luminance and high saturation, so that the constant-luminance principle is likely to be realized more accurately than in the case of a live programme from cameras, but it must be borne in mind that improvements in masking techniques are likely to overcome this limitation, at least partially.

When the Henri de France system - the early form of the SECAM system - was described at the Institution of Electrical Engineers in 1960[2], the occurrence of flickering moiré effects was predicted in the discussion[3] and a remedy incorporating one-line delays in the coder was proposed. In this report, more detailed consideration is given to the portrayal of vertical detail by the SECAM system with and without the modifications proposed to the coder. The discussion is then expanded to take account of telerecording, which may be of either the suppressed-field type in which each film frame is produced by recording only one incoming field, or the full-information type in which two interlaced fields are recorded on each film frame. In each case, three cases will be considered. In the first, both the original coder following the studio camera and the coder following the telecine are of the existing type. In

---

* This term has been used to denote the Fourier transform of brightness as a function of position in a narrow vertical strip of the picture.

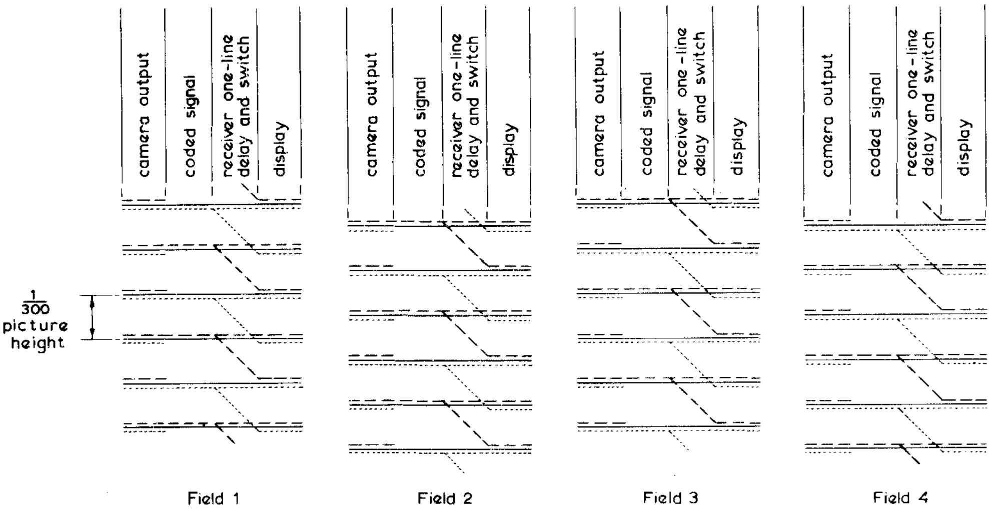

camera output
coded signal
receiver one-line delay and switch
display
$\frac{1}{300}$ picture height
Field 1
Field 2
Field 3
Field 4

Fig. 2 - Treatment of verticle detail in live transmission - existing coder

Y'——— $R' - Y'$– – – – $B' - Y'$··········

the second, it will be supposed that both coders are of the modified type, each incorporating three one-line delays. In the third case both coders are assumed to be of the original type, but a single one-line delay is used to correct misregistration between the luminance and chrominance components.

For the sake of simplicity, it will be assumed throughout this report that there are exactly 300 active lines in each field.

2. LIVE TRANSMISSION

In the first place it will be assumed that the coder and decoder are of the existing types shown in Fig. 1, in which all components irrelevant to the discussion have been omitted. It will be seen that the two colour-difference signals are transmitted alternately, and that the decoder uses a one-line delay to make both colour-difference signals available simultaneously at all times. During the reproduction of any one scanning line by the display tube, the luminance component and one of the colour-difference components is derived directly from the incoming signal, while the other colour-difference component is derived from the signal received during the previous scanning line.

Fig. 2 indicates diagrammatically the way in which the chrominance and luminance information derived from the scene by a colour television camera is redistributed vertically by the various processes to which it is subjected. Each diagram represents a group of six adjacent scanning lines of one field; the four diagrams represent four successive fields. The full lines represent the luminance signal (Y') and the broken and dotted lines respectively represent the ($R' - Y'$) and ($B' - Y'$) signals. The column headings at the top of the diagram indicate stages in the processing of the signal.

Under 'camera output' all three lines are present, indicating that all the information is available, although at that point it is in the form of the separation signals R′, B′ and G′. In each line the coder discards one or other colour-difference component, which is seen to be absent from the coded signal. The one-line delay and switch in the receiver replaces the missing information by repeating, one line lower down, whichever colour-difference signal is available. The sloping lines indicate the downward displacement of the information by the delay. The pattern moves upwards from field to field, completing a cycle in four fields (80 ms).

The flickering produced at horizontal edges results from the fact that information regarding one colour-difference component is taken from only 150 scanning lines in each field. Thus in an extreme case, if the scene contained 150 horizontal red stripes alternating with 150 grey stripes, with a pitch exactly matched to the spacing between scanning lines, these might give the effect of a uniform red for Fields 1, 5 etc. and a uniform grey for Fields 3, 7 etc., producing a 12½ c/s flicker. Flickering moiré effects of this kind can be seen without close viewing; they result from the production of spurious information at low vertical spatial frequencies from true information at high or fairly-high vertical spatial frequencies. These effects depend on from where in the scene information is taken, rather than on where in the image this information is displayed.

In addition to the moiré effects referred to above, blurring will result from the fact that colour-difference information appropriate to one scanning line is reproduced on a pair of adjacent scanning lines in each field. It will also be clear from Fig. 2 that on the average colour-difference information is displaced downwards by 1/600 of the picture height, since half the information is displaced by 1/300 of the picture height.

3. USE OF MODIFIED CODER FOR LIVE TRANSMISSION

Fig. 3 shows in outline the modified coder proposed to eliminate those moiré effects peculiar to the SECAM system. The concept underlying this proposal derives from the well-known fact that spurious components resulting from a sampling process may be avoided by restricting the bandwidth of the signal before sampling. Since the independent variable with respect to which sampling is performed is not time but vertical position, it is necessary to attenuate the higher vertical spatial frequencies before sampling. This is done by passing each of the colour-difference signals through a one-line delay and averaging the input and output of this delay. It may be shown that this process produces a zero in the vertical spectrum[1] at a vertical spatial

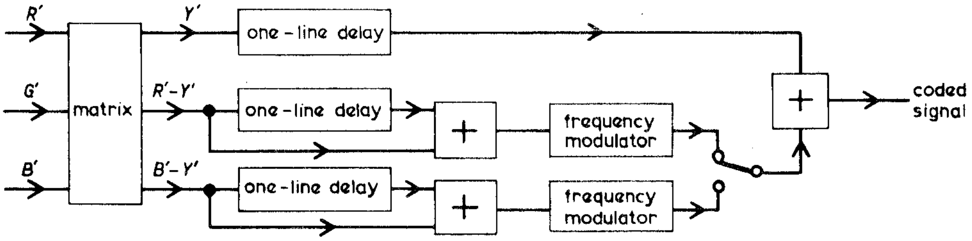
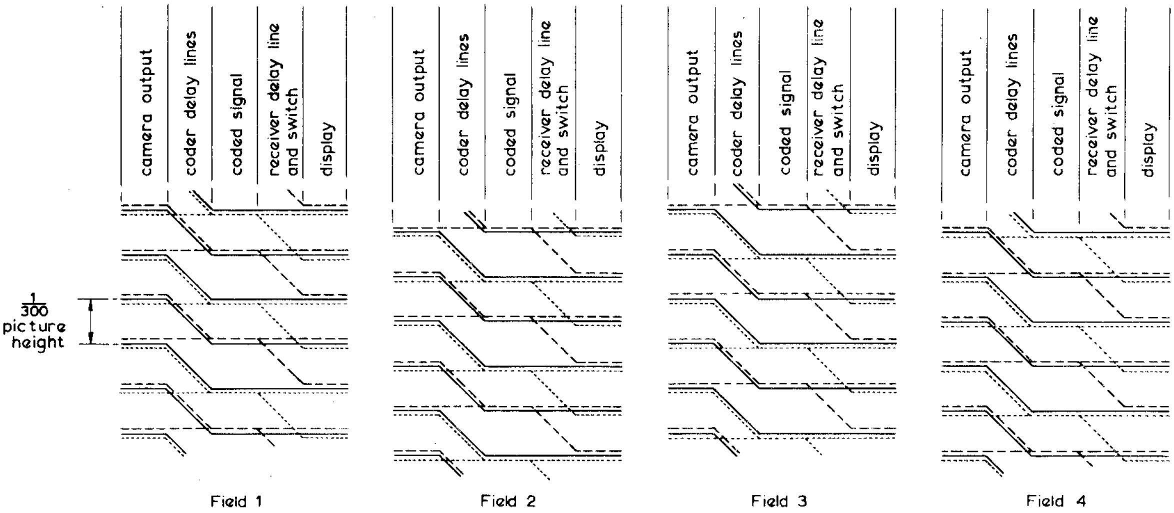


Fig. 3 - Modified coder



Field 1 Field 2 Field 3 Field 4

Fig. 4 - Treatment of vertical detail in live transmission - modified coder

Y'——— R' - Y'- - - - - B' - Y'..........

frequency of 150 cycles per picture height, the frequency from which the sampling process would otherwise generate a spurious component of zero vertical spatial frequency.

It would be possible to reduce from three to two the number of line-period delays by incorporating an additional switch to enable one line-period delay to delay the R' - Y' and B' - Y' signals* alternately.

Fig. 4 shows the way in which the treatment of the chrominance information is modified. To avoid undue complication in this figure and later figures, lines indicating colour-difference information that will eventually be discarded have been omitted. It will be seen that the coder delay lines combine together colour-difference information from two successive scanning lines. As a result, colour-difference information derived from every one of the original scanning lines is used to form the coded signal, so that low-frequency moiré patterns are not produced by the sampling process.

A further degree of blurring of the colour-difference information has been produced, since this may be reproduced either on the same line or on the next line below or two lines below. On the other hand, the average displacement of colour-difference information from its original position is now one whole scanning line, so that it can be corrected by the one-line delay in the luminance channel.

4. FILM TELERECORDING AND TELECINE WITH EXISTING CODERS

4.1. Suppressed-field Telerecording

Suppressed-field telerecording will be considered in the first instance, and it will be assumed that spot wobble in the telerecorder has just sufficient amplitude to remove the line structure.

---

* Throughout this report R', B' and G' represent the gamma-corrected primary signals and Y' an NTSC luminance signal.

It is necessary to consider the portrayal of vertical detail as a function of vertical position in the scene because it will depend on the relative positions of the scanning lines in the telerecorder and those in the telecine machine. It is usual for telecine machines to under-scan by about 5% in order to avoid revealing the edges of the recorded raster, so that the relative phases of the rasters used for telerecording and for re-scanning will vary cyclically down the picture. Each of the diagrams shown vertically one below the other in Fig. 5 corresponds to a sample of the raster taken throughout a single beat cycle; there will be about 7 cycles in the picture height.

Consider in the first place, the column marked 'Field 1', which corresponds to the first of the two fields derived by scanning one film frame. The top diagram represents parts of the picture in which the telerecording and telecine rasters are in perfect register and in which that colour-difference component which was available directly at the telerecording decoder input is the one selected by the telecine coder switch.

For example, consider the line beginning at A. (R′ - Y′) information (dashed line) is present in the coded signal and proceeds directly to the telerecorder display and is recorded on the film. It is supposed that when information is read from this line of the film in the scanner it is accepted by the switch of the coder following the scanner and is broadcast in the coded signal (see C). In the receiver the information will also be delayed in the receiver decoder and displayed one line lower at E.

It would have been possible to show another dashed line proceeding obliquely downwards from B to F, representing (R′ - Y′) information that is delayed in the decoder. This is ultimately recorded on the film at G. However, any (R′ - Y′) information at G would be rejected in the coder following the telecine machine. As already stated in Section 3, lines indicating information that will eventually be discarded are omitted.

It follows from the preceding description that if instrumental imperfections are neglected, no degradation of vertical resolution in Field 1 has been introduced by the telerecording process in those parts of the picture corresponding to the top diagrams of Fig. 5.

In the third diagram of the 'Field 1' column the rasters are again perfectly registered, so that vertical luminance resolution is preserved, but in this case that colour-difference component which was available at the telerecorder decoder input is rejected (no dashed or dotted lines at positions such as R) by the telecine coder switch. In those parts of the picture corresponding to this diagram the colour-difference information in Field 1 is displaced downwards by, on average, 1/200 of the picture height; that is to say it is misregistered with respect to the luminance information by three times as much as in the live SECAM picture.

The second and fourth diagrams in the 'Field 1' column represent intermediate cases in which the telecine and telerecording scanning rasters are not in register so that information from two recorded scanning lines is averaged by the spot wobble process. There is here a loss of vertical luminance resolution which has nothing to do with the colour system. As an example of the treatment of the chrominance information consider the (R′ - Y′) information in the coded signal at H. This will be

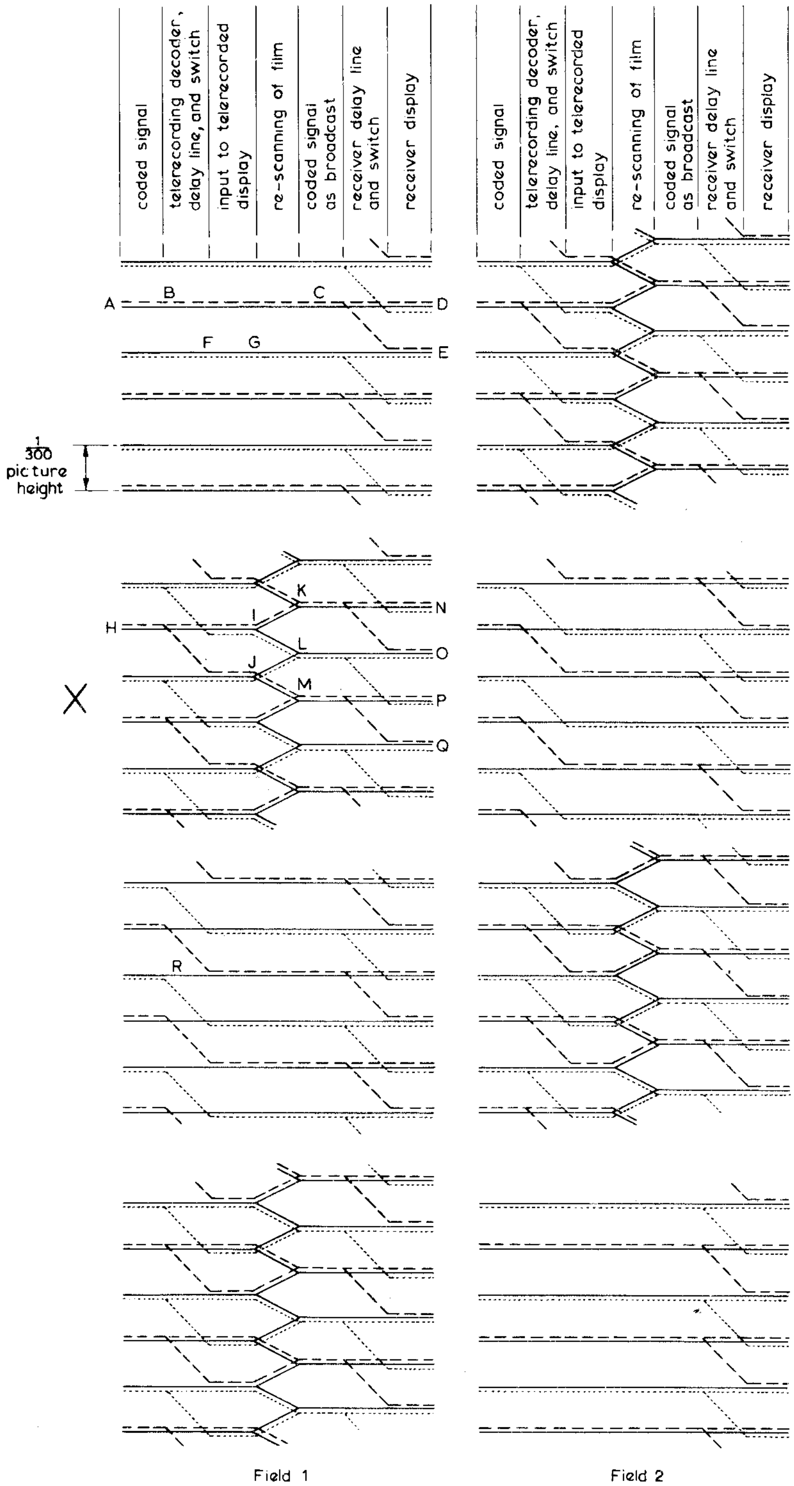

coded signal
telerecording decoder, delay line, and switch
input to telerecorded display
re-scanning of film
coded signal as broadcast
receiver delay line and switch
receiver display
coded signal
telerecording decoder, delay line, and switch
input to telerecorded display
re-scanning of film
coded signal as broadcast
receiver delay line and switch
receiver display
A
B
C
D
E
F
G
1/300 picture height
H
I
J
K
L
M
N
O
P
Q
X
R
Field 1
Field 2

Fig. 5 - Treatment of vertical detail in suppressed-field telerecording - existing coders (The four pairs of diagrams arranged vertically represent four positions in the beat pattern, 7 cycles of which occupy the picture height)

Y'——— R' - Y'— — — B' - Y'.........

displayed in the telerecorder at I and J, in the latter case following delay in the telerecorder decoder. Information displayed at I will appear in the scanner output at K and L, and that displayed at J will appear in the scanner output at L and M. However (R′ - Y′) information in the scanner output at L will be rejected by the switch in the coder following the scanner. When the effect of delay in the receiver is taken into account R′ - Y′ information at K is found to be displayed at N and O and that from M is found to be displayed at P and Q. Thus colour-difference information available at the input of the decoder of the telerecorder is ultimately displayed on four adjacent lines. The mid-point of these lines (between O and P) is 1/300 of the picture height below H, so that the misregistration between luminance and chrominance is twice as much as in a live transmission. Moreover the blurring of the chrominance information has been accentuated, since information produced by the camera during one scanning line contributes to four adjacent scanning lines (of a field) in the displayed picture.

Referring to the fourth diagram of the 'Field 1' column, it is seen that here also there is misregistration of 1/300 of the picture height between the luminance and chrominance information, but there is less blurring of the chrominance information, in that information apertaining to one scanning line is reproduced on only two adjacent lines.

The column labelled 'Field 2' indicates the second field derived in the telecine from the film frame under consideration. The diagrams are identical to, but displaced vertically from, those of the first field. For a complete presentation of the phenomena, it would be necessary to show the third and fourth fields of the 80 ms cycle (these would be derived from the next film frame), but it is not essential to show these because they would closely resemble Field 1 and Field 2 respectively, the only difference between the diagrams being an interchange between the dashed and dotted lines.

Consider a sequence of complete pictures generated by the picture source, each picture comprising two interlaced fields and being recorded on one film frame. All the information in the second field of each picture is discarded by the suppressed-field recorder and in the first field one colour-difference component is discarded by one or other coder in each scanning line, R′ - Y′ and B′ - Y′ being discarded in alternate pictures. The colour-difference component that is not discarded is treated in precisely the same way in every picture; it is distributed to the same extent between two or four adjacent lines and it suffers the same average downward displacement. It follows that there will be a permanent difference between the treatment of vertical detail in different parts of the picture. This will be considered later.

The flickering moiré patterns peculiar to the SECAM system, which depend on from where in the scene samples of colour-difference information are taken, will not be affected greatly by the telerecording process. The slight effect of telerecording on these patterns may be explained by the following argument. It was pointed out that in a live SECAM picture, information relating to one particular colour-difference component will be selected from 150 horizontal lines which move upwards by 1/600 of the picture height between fields. In scanning a suppressed-field telerecording the 150 lines will remain in the same place for two successive displayed fields (derived from the same film frame) and will then move upwards by 1/300 of the picture height.

The moiré pattern will tend to alternate abruptly in phase with a periodicity of 12½ c/s instead of running through with the same periodicity. It is not thought that this will have much effect on the annoyance caused.

Another feature of suppressed-field telerecording indicated in Fig. 5 is that in parts of the picture the misregistration between chrominance and luminance fluctuates from field to field. This will happen at 25 c/s and will probably not be important.

4.2. Full-information Telerecording

Each film frame of a full-information telerecording is made up of two interlaced fields, so that the amplitude of the spot wobble used is only half of that required in a suppressed-field telerecording. Nevertheless, there will still be a distinction between the first and second fields derived from each film frame. The variation in the portrayal of vertical detail as a function of vertical position in the picture is now somewhat more complicated and twice as many diagrams have therefore been provided in Fig. 6 as in Fig. 5. Together the eight pairs of diagrams cover one beat cycle between the telerecorded and the telecine rasters, and as before there are about seven cycles in the picture height.

As in the case of suppressed-field telerecording, diagrams could have been provided for Field 3 and Field 4 but these would have been the same as those for Field 1 and Field 2 respectively, except that they would have been displaced upwards by 1/300 of the picture height.

One conclusion that can be drawn from Fig. 6 is that although the use of full-information telerecording as compared with suppressed-field telerecording greatly improves the portrayal of vertical luminance detail, it does not greatly improve the portrayal of vertical colour-difference detail.

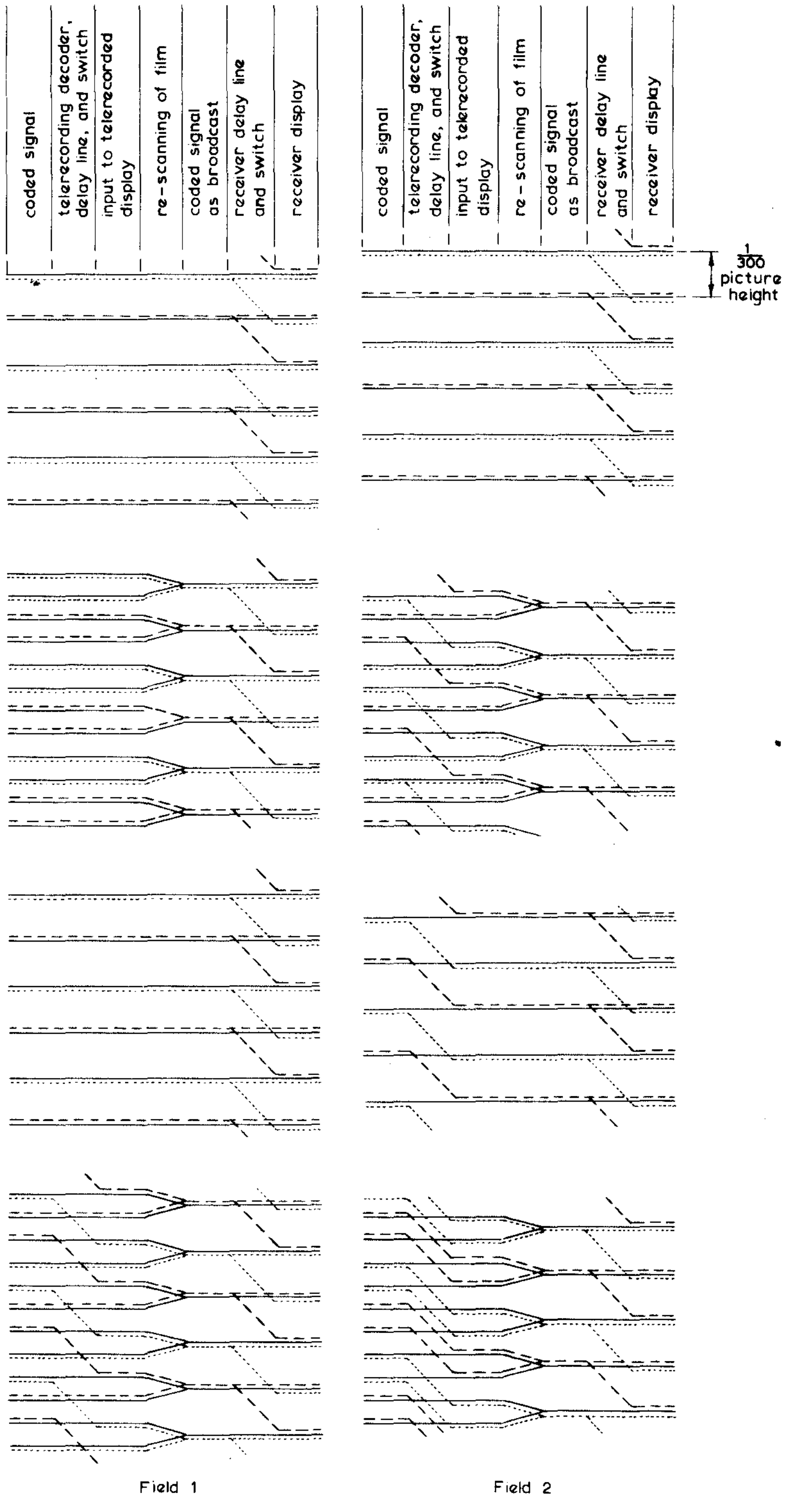
It will be seen that each displayed field incorporates information about any one colour-difference component that was obtained, not from 150 lines as in a live transmission or a suppressed-field telerecording, but from 150 pairs of adjacent lines (i.e. adjacent lines in a picture). Although the moiré patterns should alternate abruptly in phase at 12·5 c/s, as in the case of suppressed-field telerecording, they should be reduced in amplitude by about 3 dB.

5. A SIMPLER METHOD OF REPRESENTATION

Before proceeding to examine more complicated systems, it is necessary to adopt a simpler kind of diagram to illustrate the portrayal of vertical detail. The kind of diagram used up to this point illustrates:

(i) the way in which colour-difference information is selected by the original picture source from alternate lines. This selection determines the flickering moiré effects at horizontal boundaries between different colours.

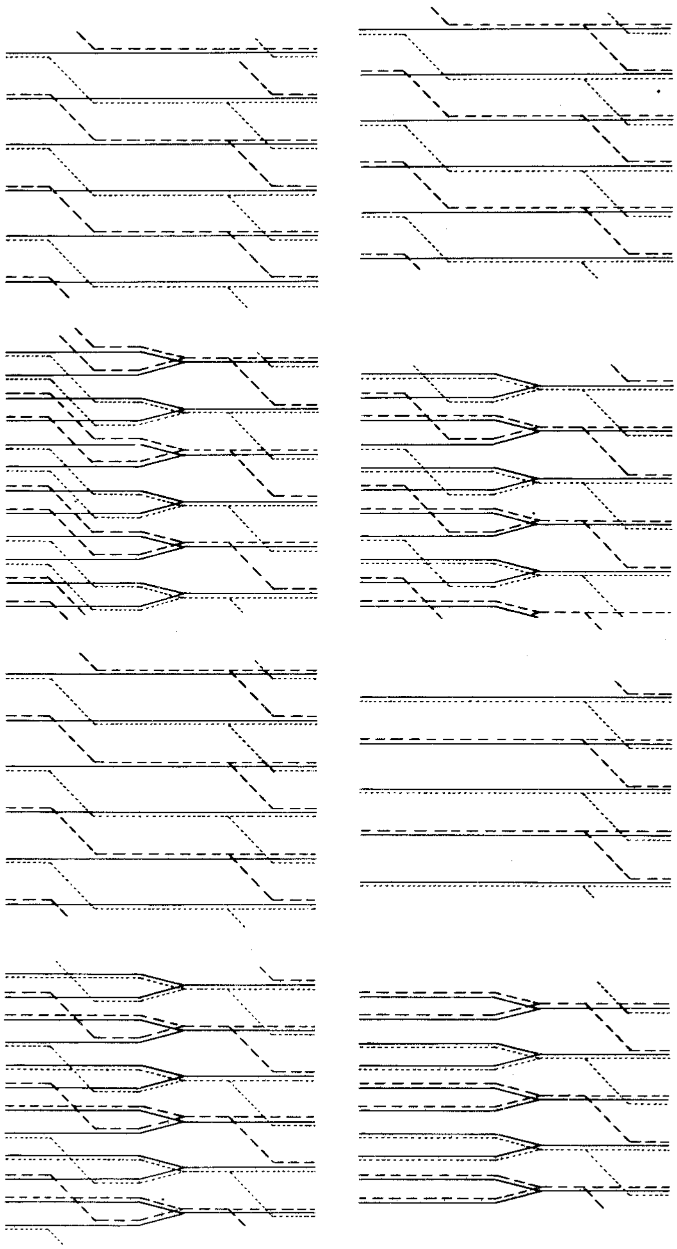
(ii) the way in which chrominance information is blurred by distribution information from one line between two or more lines, and


coded signal
telerecording decoder, delay line, and switch
input to telerecorded display
re-scanning of film
coded signal as broadcast
receiver delay line and switch
receiver display
coded signal
telerecording decoder, delay line, and switch
input to telerecorded display
re-scanning of film
coded signal as broadcast
receiver delay line and switch
receiver display
1/300 picture height
Field 1
Field 2

(continued on opposite page)

(*a*) Upper half

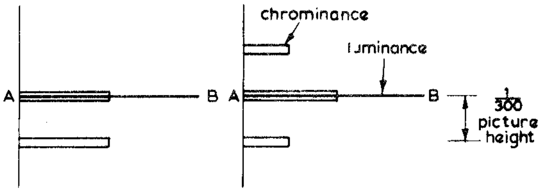
(continued from opposite page)



(b) Lower half

Fig. 6 - Treatment of vertical detail in full-information telerecording - existing coders (The eight pairs of diagrams arranged vertically represent eight positions in the beat pattern, 7 cycles of which occupy the picture height)

Y′ ——— R′ - Y′— — — — B′ - Y′-----------



(a) Existing coder

(b) Modified coder

Fig. 7 - Simpler diagram applied to live transmission

(iii) the vertical misregistration between chrominance and luminance information.

It will become clear that the new arrangements to be examined either eliminate (i) or leave it as it was in the arrangements already considered. It is therefore convenient to adopt a simpler diagram which illustrates (ii) and (iii) only. This diagram is illustrated in Fig. 7 for a live transmission, using either the existing coder or the modified coder of Fig. 3. Here the centre line AB indicates the position of the luminance component whether it has been subjected to a one-line delay or not. Lines and blocks marked 'luminance' and 'chrominance' in the diagram indicate the displacement of information upwards or downwards from its original position. For convenience, any average displacement of luminance information will be ignored. In the existing coder, luminance information is unaffected but half the chrominance information is displaced downwards by 1/300 of the picture height. The modified coder leaves the luminance and half the chrominance information in its original position but displaces a quarter of the chrominance information upwards and a quarter of the chrominance information downwards, in each case by 1/300 of the picture height.

The modified coder was proposed in order to avoid the moiré patterns peculiar to the SECAM system, it would therefore be reasonable to accept some blurring of the chrominance information in return, but it is by no means certain that the modified coder would in fact detract from sharpness; although the colour-difference information is more widely spread vertically, its 'centre of gravity' is now correctly in register with the luminance information. If the criterion of sharpness proved to be the displacement of the chrominance information from the luminance information rather than from its own 'centre of gravity', the use of the modified coder would have no effect whatsoever on the sharpness.

In Fig. 9 the same type of diagram has been applied to suppressed-field telerecording. In the first pair of columns, which apply to conventional coders, each of the diagrams corresponds to one diagram of Fig. 5.

For example, consider the second diagram (marked 'X') in the first column, which corresponds to the second diagram (also marked 'X') of the first column of Fig. 5. It will be seen from the latter diagram that luminance information generated by the camera during one scanning line (for example, that corresponding to H) is ultimately displayed on two adjacent scanning lines of a field (N and O). This is indicated in Fig. 9 by the two solid horizontal lines spaced 1/300 picture height apart. On the other hand, chrominance information from H is ultimately displayed on the four consecutive lines N, O, P, Q; this is indicated in Fig. 9 by the four hollow blocks, the upper two of which coincide with the solid lines representing luminance information.

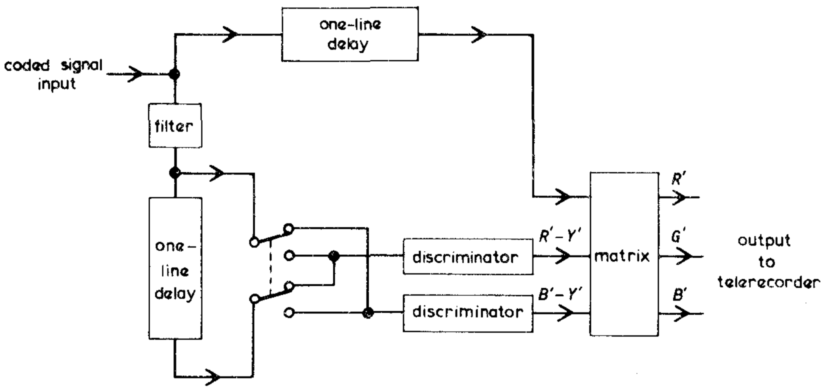


Fig. 8 - Use of line-period luminance delay for telerecording

It will be seen that, for conventional coding, when a suppressed-field telerecording is re-scanned the chrominance information is on the average blurred symmetrically and is displaced on the average by 1/300 of the picture height below the luminance information, this is twice the misregistration in a live transmission with conventional coding. Moreover, some of the chrominance information is displaced as much as 1/120 of the picture height from its correct position.

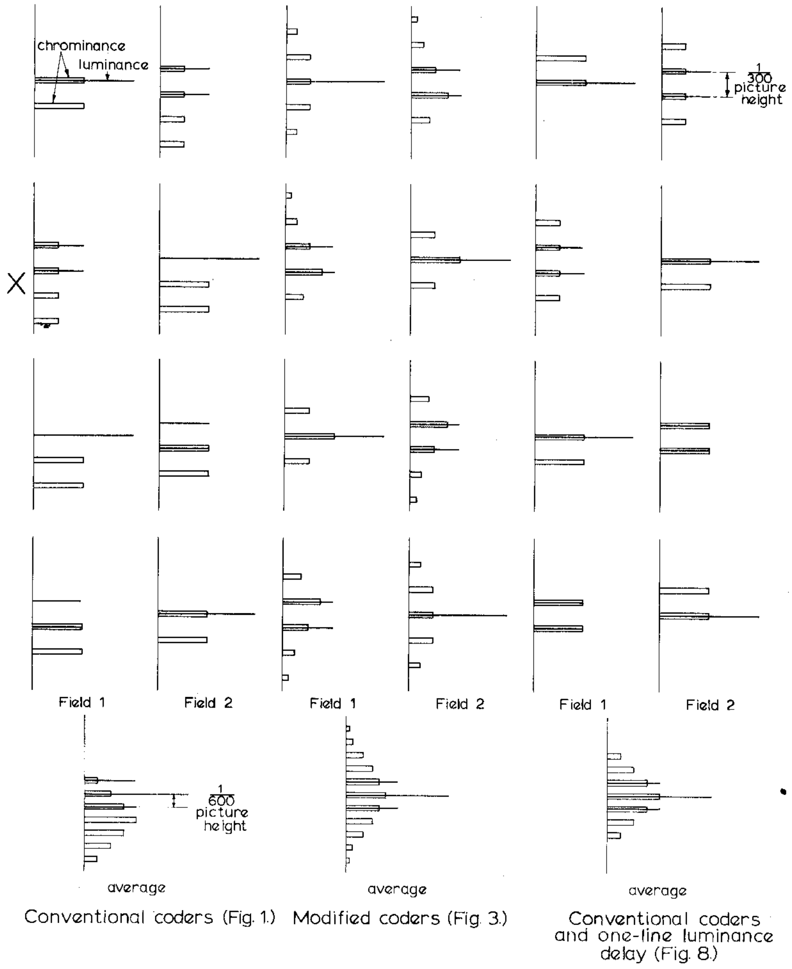
The second set of diagrams in Fig. 9 assumes that both the coder following the original picture source and the coder following the telecine machine are of the modified type proposed in Fig. 3. Each of these was derived by considering the corresponding diagram of Fig. 5, deducing the effect of using modified coders, and finally representing the result in histogram form. It would be tedious to go through this process here. The chrominance information has now been spread out more than with conventional coders, but the misregistration between luminance and chrominance averaged over one vertical beat cycle, has been avoided.

Since the average misregistration between luminance and chrominance when conventional coders are used is equal to the interval between scanning lines in one field, it can be eliminated by using a line-period delay in the luminance channel at some point in the process.* The additional delay could be incorporated either in the decoder associated with the telerecorder, as shown in Fig. 8, or in the coder associated with the scanner; the former position would be the most economical. The effect is illustrated by the third set of diagrams in Fig. 9. It must, of course, be emphasized that the use of conventional coders together with the one-line luminance delay would not affect the flickering moiré patterns peculiar to SECAM, but it is seen that the misregistration is, on average, corrected with less blurring of the chrominance information than would result from the use of the modified coders.

Fig. 10 illustrates the treatment of vertical detail in a full-information telerecording. The diagrams in the first two columns of the Figure, which apply to conventional coding, correspond to the diagrams in Fig. 6. A comparison between

---

* This arrangement would also be worth using if PAL is adopted. The modified coders are not required for PAL, which is free from moiré effects, but delay-line decoders produce misregistration which is, on the average, the same as that produced by SECAM decoders.



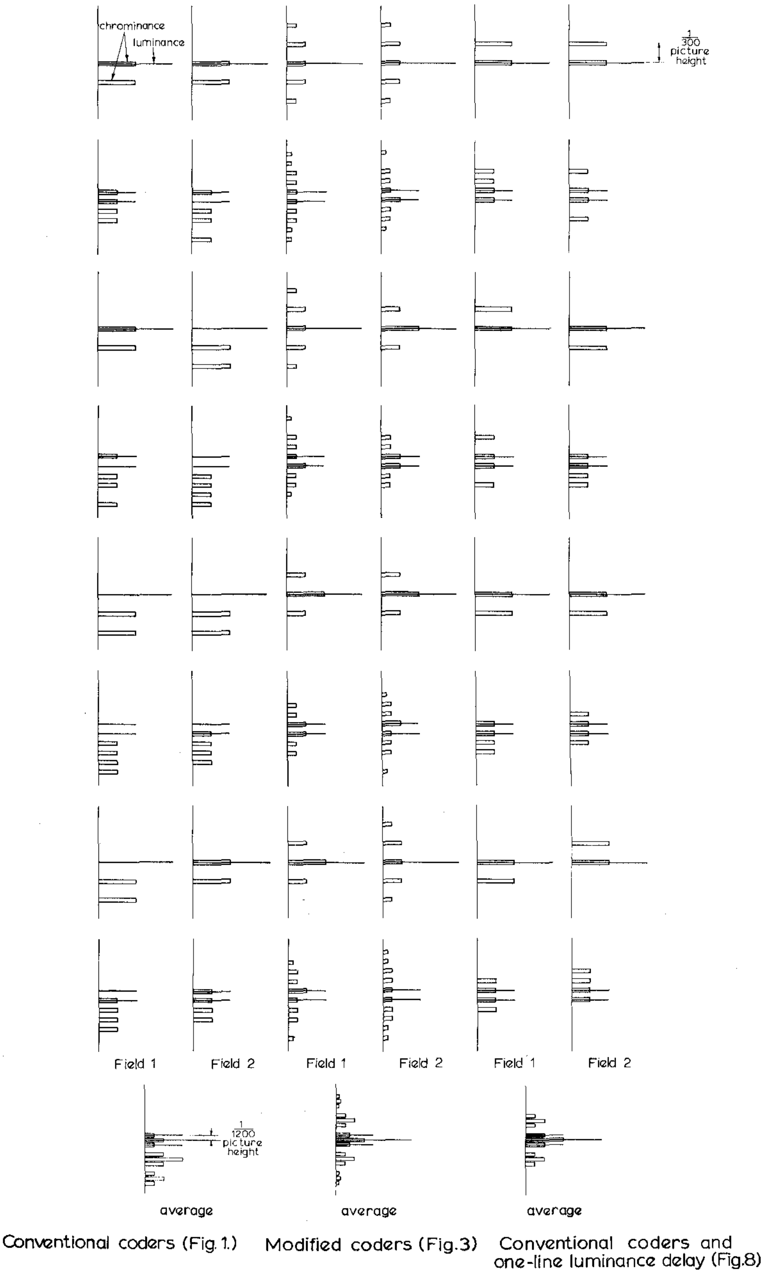
Conventional coders (Fig. 1.) Modified coders (Fig. 3.) Conventional coders and one-line luminance delay (Fig. 8.)

Fig. 9 - Chrominance sharpness and chrominance-luminance registration in a suppressed-field telerecording (The four sets of diagrams arranged vertically represent four positions in one cycle of the beat pattern, 7 cycles of which occupy the picture height)

Figs. 9 and 10 shows the superiority of full-information telerecording in respect of luminance sharpness. Phenomena associated only with chrominance are more complex than with suppressed-field telerecording, but the effects are similar in magnitude, so that the practical conclusions are much the same.

6. DISCUSSION

The flickering moiré effects have not appeared important in most pictures, but they can occasionally appear objectionable. One example is a half-length shot of a person taking part in a dialogue - particularly a woman with saturated lipstick. Because expression is conveyed mostly by the lips they tend to be watched closely during a conversation, and a flickering effect can be irritating. This effect seemed to be noticed less often in the later tests and demonstrations of SECAM - possibly because the more saturated lipsticks (which by the failure of the constant luminance



Conventional coders (Fig. 1.) Modified coders (Fig.3) Conventional coders and one-line luminance delay (Fig.8)

Fig. 10 - Chrominance sharpness and chrominance-luminance registration in a full-information telerecording (The eight sets of diagrams arranged vertically represent eight positions in one cycle of the beat pattern, 7 cycles of which occupy the picture height)

principle can give rise to a *luminance* flicker) have become less fashionable. These effects would be effectively eliminated by the use of the modified coder of Fig. 3, but would be affected only slightly by telerecording.

In recent experiments[4] using magnetic recordings of coded signal from a colour camera, observers graded the impairment of vertical detail on a 6-point scale in which '1' represented 'Imperceptible' and '2' represented 'Just Perceptible'. The mean grades allotted to NTSC and SECAM were 1·23 and 1·87 respectively. In a comparison between NTSC and PAL (using slightly different material) the mean grades were 1·14 and 1·36 respectively.

To assist in assessing the importance of blurring of the chrominance information and its misregistration with respect to luminance, both effects occurring only vertically, it is convenient to compare the analogous horizontal effects. These would result from a difference in delay between luminance and chrominance signals and from bandwidth restriction of the chrominance channel. In fact the horizontal displacement that would be caused by a delay of 130 ns is equal to the distance between adjacent scanning lines in one field (1/300 of the picture height).

As an example we may consider the simplest case: a live transmission with conventional coding (see Fig. 7*a*). Here the 'centre of gravity' of the chrominance information has been displaced by 1/600 picture height from the luminance information; the analogous horizontal effect is a group delay, relative to the vision carrier, of 65 ns in the chrominance band. The vertical blurring of chrominance is equivalent to the horizontal blurring due to a network whose impulsive response is two impulses spaced by 130 ns. Such a network would have a sinusoidal amplitude/frequency response falling to -6 dB at 2·6 Mc/s and to zero at 3·8 Mc/s.

Table 1 shows the values of chrominance bandwidth and chrominance group delay that would produce horizontal effects equivalent to the vertical effects caused by the SECAM system. Henceforth the values given in Table 1 will be referred to as the 'equivalent chrominance bandwidth' and 'equivalent chrominance group delay'. In the case of telerecordings, these effects vary cyclically down the picture, so the table shows both the worst value (greatest chrominance group delay or smallest chrominance bandwidth) and the value averaged over the picture. The number of active lines per picture is assumed to be 581 rather than the round figure 600 which has been assumed for simplicity up to this point.

Table 1 shows that telerecording reduces the equivalent chrominance bandwidth and that, when conventional coders are used, it increases the equivalent group delay - on the average doubling it. As might be expected full-information telerecording involves slightly less loss of equivalent chrominance bandwidth than does suppressed-field telerecording. On the other hand full-information telerecording results in a greater *maximum* (but not average) value of the equivalent group delay.

When modified coders are used the equivalent group delay is zero everywhere, implying that misregistration between luminance and chrominance is avoided everywhere, but the equivalent chrominance bandwidth is further reduced. The use of conventional coders in conjunction with a line-period luminance delay eliminates the average misregistration, but only reduces the worst misregistration.

If conventional coders are used the lowest equivalent chrominance bandwidth obtained anywhere is 1·51 Mc/s (for suppressed-field telerecording). The effect of this is probably observable but not serious. The greatest equivalent chrominance group delay, 201 ns, is thought to be undesirably high. In this connection it may be remarked that the NTSC specification requires any mis-timing of the chrominance signal relative to the luminance signal to be less than 50 ns. The lowest equivalent chrominance bandwidth obtained by the use of modified coders is 1•17 Mc/s; such a degree of blurring of the chrominance information is thought to be undesirable, but less so than misregistration equivalent to 200 ns of chrominance group delay.

TABLE 1
Equivalent Chrominance Bandwidth and Group Delay

CODING		LIVE TRANSMISSION	SUPPRESSED-FIELD TELERECORDING	FULL-INFORMATION TELERECORDING
Conventional coders	Bandwidth	2•48(2•48) Mc/s	1•51(1•70) Mc/s	1•70(1•81) Mc/s
	Group delay	67(67) ns	168(134) ns	201(134) ns
Modified coders	Bandwidth	1•86(1•86) Mc/s	1•14(1•30) Mc/s	1•17(1•34) Mc/s
	Group delay	0	0	0
Conventional coders with line-period luminance delay	Bandwidth	-	1•51(1•70) Mc/s	1•70(1•81) Mc/s
	Group delay	-	34(0) ns	67(0) ns

Notes 1. Odd and even fields are averaged. This ignores effects flickering at 25 c/s.

2. The result given first is the worst value obtained as above when all points in the beat cycle are considered.

3. The result given in brackets is obtained by averaging over the beat cycle.

4. The bandwidth is the frequency at which the response has fallen by 6 dB.

5. It is assumed that the active line duration is 52•0 μs and that there are 290½ active lines per field.

7. CONCLUSIONS

The flickering moiré patterns associated with the SECAM system are not much affected by telerecording. In any case the modified coder (which incorporates three one-line delays) will avoid these effects. It is not expected that the use of modified coders will impair the sharpness of a live transmission since the blurring of the chrominance information is likely to be offset by the improved registration between luminance and chrominance.

When a colour signal is derived from a film telerecording, the use of the SECAM system both before and after telerecording results in a slight vertical blurring of the chrominance information together with an undesirable degree of vertical misregistration between chrominance and luminance. If modified coders are used the misregistration is avoided, but the vertical blurring of the chrominance information is increased; on the whole it is thought that the result will be beneficial. It is assumed that these coders would follow both the original picture source and the telecine machine, since it would clearly be undesirable to distinguish operationally between signals that are to be transmitted live and those that are to be telerecorded, or to distinguish between a telecine scanning a telerecording and one scanning optical film. In any case, it is not thought that there would be any significant advantage in so doing.

If conventional coders are used it is recommended that a line-period luminance delay be incorporated in the decoder preceding the telerecorder. This will largely, though not entirely, overcome the vertical misregistration between chrominance and luminance without in any way increasing the vertical blurring of the chrominance information. This arrangement would not affect the flickering moiré patterns (which are not much affected by telerecording), but would be well worth while if it were decided for other reasons not to use modified coders at all. It is, however, thought preferable to use modified coders throughout.

The use of a line-period delay in the luminance channel of the decoder preceding a telerecorder is always advantageous in the case of the PAL system. This system is in any case free from the flickering moiré effects peculiar to SECAM.

8. REFERENCES

1. MONTEATH, G.D.: 'Vertical Resolution and Line Broadening', BBC Engineering Monograph No. 45, December 1962. (Based on BBC Research Department Report No. T-082, Serial No. 1962/5.)

2. CHASTE, R. and CASSAGNE, P.: 'Henri de France Colour Television System', Proc.Instn.Elect.Engrs., 1960, (**107B**, 36, pp. 499 - 507).

3. MONTEATH, G.D., discussion on reference 2, Proc.Instn.Elect.Engrs., **107B**, p. 510.

4. 'Some Subjective Comparisons of Vertical-Edge Effects and Vertical Resolution in the NTSC, PAL and SECAM III Colour Television Systems', Research Department Technical Memorandum No. T-1074, January 1965.

SMW

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey